



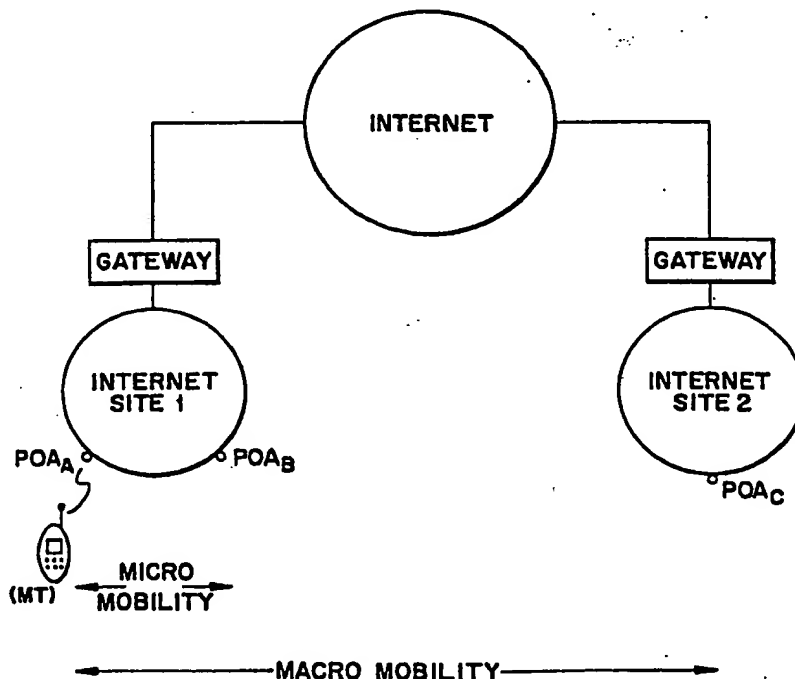
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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|---|--|---|---|
| (51) International Patent Classification 7 :<br><b>H04L 29/06, 12/18, 12/28, H04Q 7/38</b>  |  | A1  | (11) International Publication Number:<br><b>WO 00/54475</b>      |
|   |  |   | (43) International Publication Date: 14 September 2000 (14.09.00) |
| (21) International Application Number: <b>PCT/SE00/00458</b><br>(22) International Filing Date: <b>8 March 2000 (08.03.00)</b><br>(30) Priority Data:<br>09/264,860          9 March 1999 (09.03.99)          US<br>(71) Applicant: <b>TELEFONAKTIEBOLAGET LM ERICSSON</b><br>(publ) [SE/SE]; S-126 25 Stockholm (SE).<br>(72) Inventors: <b>EKLUND, Thomas; Folkungagatan 58, S-116 22 Stockholm (SE). BRAATHEN, Magnus; Nynäsvägen 54, S-136 40 Stockholm (SE).</b><br>(74) Agent: <b>MILDH, Christer; Ericsson Radio Systems AB, Ericsson Research/Patent Support Unit, S-164 80 Stockholm (SE).</b> |  | (81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).<br><br>Published<br><i>With international search report.<br/>         Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i> |   |

(54) Title: MULTICAST HANDOVER FOR MOBILE INTERNET PROTOCOL

## (57) Abstract

In a mobile Internet Protocol (IP) environment, intra-site handovers are more efficiently and effectively accomplished by employing a hierarchical, double-protocol approach to mobility management. At the Internet site level, IP data packets destined for a visiting mobile terminal are tunneled from an Internet site level node called a Mobility Management Agent (MMA) to the mobile terminal in accordance with a Multicast routing protocol and the mobile terminal's Multicast address. Outside the Internet site, the IP data packets are routed between the MMA and correspondent nodes in accordance with the rules and procedures associated with Mobile IP, particularly Mobile IP version 6. By employing a Multicast routing protocol at the Internet site level, the mobile terminal need not re-register with its home agent or the MMA each time it undergoes an intra-site handover, thereby conserving time and network overhead, resulting in a more efficient and effective handover procedure.



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## MULTICAST HANDOVER FOR MOBILE INTERNET PROTOCOL

### FIELD OF INVENTION

5           The present invention involves the field of telecommunications. More particularly, the present invention involves the field of mobile telecommunications and the Mobile Internet Protocol.

### BACKGROUND

10           The network-layer protocol associated with the Internet is appropriately called the Internet Protocol (IP). In general, the IP connects the various networks and subnetworks which make up the Internet by defining, among other things, the rules and procedures which govern the way IP data packets are routed from a source node to a destination node. To ensure that IP data packets are correctly  
15           routed, every node is assigned an IP address, wherein the IP address defines a fixed network location associated with a correspondent node. While the IP adequately handles the routing of data between fixed network nodes, it does not adequately handle the routing of IP data packets to and/or from mobile nodes.

          In contrast, the Mobile Internet Protocol (i.e., Mobile IP) was designed to  
20           specifically handle the routing of IP data packets to and/or from mobile nodes (i.e., mobile terminals which frequently change their point-of-attachment to the Internet). Moreover, Mobile IP was designed to handle the routing of IP data packets to and/or from mobile nodes without significantly interrupting on-going communications and without requiring mobile nodes to restart applications.

25           Mobile IP supports mobility, in part, by assigning two IP addresses to each mobile node, herein referred to as mobile terminals. The first of these IP addresses is known as the home address. The home address is a permanent IP address, and it is associated with a mobile terminal's point-of-attachment in the mobile terminal's home network. The second IP address is called the care-of-  
30           address. The care-of-address is assigned to a mobile terminal when the mobile terminal moves and attaches to a foreign network. Unlike the mobile terminal's

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home address, the care-of address is a temporary address. The care-of address is a temporary address because it changes whenever the mobile terminal undergoes a handover procedure from one point-of-attachment to another in a foreign network.

Presently, there are two versions of Mobile IP that have been proposed by the Internet Engineering Task Force (IETF): Mobile IP version 4 (MIPv4) and Mobile IP version 6 (MIPv6). Briefly, Mobile (IPv4) works as follows.

Whenever a mobile terminal moves, and in so doing, attaches to the Internet through a foreign network, the mobile terminal informs a special node, herein referred to as the mobile terminal's home agent, as to its new care-of address. This process involves sending the home agent both the current care-of-address and the home address. The process is also referred to as a registration or binding update.

After the mobile terminal registers its new care-of address with the home agent, the home agent is able to serve as a proxy host for the mobile terminal. Accordingly, IP data packets addressed to the mobile terminal (i.e., the mobile terminal's home address) will be intercepted by the home agent. The home agent then encapsulates the IP data packet so that the destination address reflects the mobile terminal's care-of address. The data packet is then sent from the home agent to the mobile terminal's care-of address. When the IP data packet arrives at the care-of address, the IP data packet is retransformed or de-capsulated by stripping away the care-of address so that the mobile terminal's home address once again appears as the destination address. The IP data packet can then be delivered to the mobile terminal, wherein the data contained therein can be processed by the appropriate higher level protocols (e.g., TCP or UDP), as one skilled in the art will readily appreciate.

There are a number of drawbacks associated with MIPv4. For example, network nodes generally have no way of knowing whether another node is a mobile node. Accordingly, if they wish to send IP data packets to another node, they must always do so by indirectly sending IP data packets through the other

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node's home address, as explained above. This indirect routing of IP data packets adds delay to the IP data packet routing process, wherein excessive delay can be extremely detrimental to delay-sensitive applications, such as voice applications. In addition, care-of-address allocation is often problematic due to the fact that the  
5 number of available care-of-addresses may be limited.

MIPv6 includes several features that were designed to overcome some of the deficiencies associated with MIPv4. One such feature, for example, is called route optimization.

In accordance with the route optimization feature, MIPv6 compatible nodes  
10 maintain a list which provides a mapping between a home address and a corresponding care-of-address for each of a number of mobile terminals. This list is maintained in, what is referred to as, a binding cache. When a mobile terminal moves, it sends a binding update message. Upon receiving the binding update message, each of the MIPv6 compatible nodes use the information contained in the  
15 binding update message to update their binding cache. The MIPv6 compatible nodes are then able to send IP data packets directly to the mobile terminal (i.e., to the mobile terminal's care-of-address) without first having to route the IP data packets through the mobile terminal's home agent. As one skilled in the art will readily appreciate, route optimization is intended to reduce IP data packet routing  
20 delay times.

Despite numerous improvements over MIPv4, MIPv6 still exhibits numerous other deficiencies. One such deficiency is the way in which MIPv6 manages micro mobility. Micro mobility involves the movement of a mobile terminal from one point-of-attachment to another within a single Internet site (i.e.,  
25 between commonly administered networks, subnetworks or LAN segments). This type of movement is herein referred to as an intra-site handover. In contrast, macro mobility involves the movement of a mobile terminal from a first Internet site to a second Internet site. Such a move is herein referred to as an inter-site handover. More specifically, MIPv6 manages micro mobility in a manner that is

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substantially similar to the way it manages macro mobility. For instance, whether a mobile terminal undergoes an inter-site handover or an intra-site handover, a binding update must be sent to the mobile terminal's home agent, and optionally to other MIPv6 compatible nodes, over the Internet. This, of course, adds  
5 unnecessary and often unacceptable delay to the handover process. These delays are most evident and unnecessary where the mobile terminal is engaged in an intra-site handover.

Techniques have been proposed to help optimize intra-site handovers in a Mobile IP environment. One such technique involves assigning each visiting  
10 mobile terminal a "site" care-of-address when it first attaches to a foreign Internet site. Thereafter, the mobile terminal sends a registration or binding update to its home agent, wherein the registration or binding update message contains the mobile terminal's site care-of-address along with its home address. In addition, the mobile terminal sends a registration message to one or more border routers  
15 associated with the foreign Internet site, wherein the border routers essentially operate as gateways by routing IP data packets into and out of the corresponding Internet site. The registration message sent to the one or more border routers contains the "site" care-of-address assigned to the mobile terminal, as well as the mobile terminal's current care-of-address. Accordingly, an IP data packet being  
20 routed to the mobile terminal's home address will be intercepted by the home agent. The home agent HA then tunnels the IP data packet to the appropriate border router in accordance with the mobile terminal's "site" care-of-address. The border router then tunnels the IP data packet to the mobile terminal located at its current care-of-address.

25 In accordance with this technique, a mobile terminal may be able to maintain the same "site" care-of-address as long as it is attached to the same foreign Internet site. If so, the mobile terminal need not re-register with its home agent each time it undergoes an intra-site handover. Nevertheless, as the mobile terminal's current care-of-address changes with each intra-site handover, it is still

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necessary to re-register with the one or more border routers so that the mapping lists maintained therein can be properly updated. Therefore, this technique may result in unnecessary and unacceptable delays in completing an intra-site handover procedure.

5           In accordance with another prior technique, a multicast protocol address is assigned to a mobile terminal, wherein a correspondent node that intends to send IP data packets to the mobile terminal, sends the IP data packets directly to the mobile terminal's Multicast address. Accordingly, a Multicast routing protocol would be needed to route the IP data packets along the entire path from the  
10           correspondent node to the mobile terminal. The primary drawback with this technique is that all of the Backbone routers across the Internet would have to be able to support the Multicast routing protocol. In addition, all Internet nodes would have to be capable of sending IP data packets to a Multicast address. In addition, this solution is not very scalable. As one skilled in the art will  
15           appreciate, providing these capabilities would be extremely cost prohibitive.

          Accordingly, it would be desirable to provide a technique that further optimizes micro mobility, and in particular, the process of accomplishing an intra-site handover described in the first exemplary embodiment above. Again, it is of importance to note that this multicast address need not be changed when the mobile  
20           terminal moves from one point-of-attachment to another during an intra-site handover, thereby making the process of managing micro mobility, including intra-site handovers, significantly more efficient. It should also be noted that while multicast addresses generally identify a number of hosts which are members of a multicast group, the multicast address being assigned in the present  
25           embodiment is to be associated with only one host, that is, one mobile terminal.

## SUMMARY OF THE INVENTION

The present invention provides a technique for optimizing micro mobility in a Mobile IP environment, and in particular, for optimizing the process of accomplishing intra-site handovers. In general, the present invention accomplishes this by providing a hierarchical, double-protocol approach to mobility management. In particular, the present invention employs the rules and procedure associated with MIPv6 to handle macro mobility requirements and a Multicast routing protocol to handle micro mobility requirements. In doing so, a mobile terminal need not re-register with its home agent, any Internet site level router, server, or the like, during an intra-site handover, thereby reducing the time required to accomplish an intra-site handover, reducing network overhead and generally improving micro mobility.

Accordingly, it is an objective of the present invention to improve intra-site handover efficiency in a Mobile IP environment.

It is still another objective of the present invention to minimize intra-site handover latency.

It is another objective of the present invention to make intra-site handovers transparent to nodes external to the Internet site to which a mobile terminal is attached.

It is yet another objective of the present invention to make intra-site handovers in a Mobile IP environment appear more seamless to the user.

In accordance with one aspect of the present invention, the above-identified and other objects are achieved by a method for routing Internet Protocol (IP) data packets between a mobile terminal and a correspondent node. The method involves routing an IP data packet from the correspondent node, over the Internet, to a mobility management agent (MMA) associated with the Internet site to which the mobile terminal is attached. This is accomplished in accordance with a Mobile Internet Protocol (Mobile IP) and a network address associated with the MMA. The method also involves routing the IP data packet from the MMA to a present



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location of the mobile terminal in the Internet site, in accordance with a Multicast routing protocol and a Multicast address which has been assigned to the mobile terminal.

5 In accordance with another aspect of the present invention, the above-identified and other objects are achieved by a method for managing the micro mobility requirements of a mobile terminal. The method involves assigning the mobile terminal a Multicast address prior to initiating a first intra-site handover of the mobile terminal from a first subnetwork to a second subnetwork, wherein the first subnetwork is the mobile terminal's home subnetwork, and wherein both the  
10 first subnetwork and the second subnetwork are associated with the mobile terminal's home Internet site. Then a binding update message is sent to the MMA associated with the home Internet site, wherein the binding update message to the MMA contains information including the mobile terminal's Multicast address. Thereafter, a binding update message is sent to the home agent associated with the  
15 mobile terminal, wherein the binding update message to the home agent contains information including the home address associated with the mobile terminal.

In accordance with still another aspect of the present invention, the above-identified and other objects are achieved by a method for managing the micro mobility requirements of a mobile terminal. The method involves assigning the  
20 mobile terminal a Multicast address prior to initiating an inter-site handover of the mobile terminal to a point-of-attachment associated with a foreign Internet site. A binding update message is then sent to the MMA associated with the foreign Internet site, wherein the binding update message to the MMA includes the home address for the mobile terminal and the mobile terminal's Multicast address. The  
25 mobile terminal is also assigned a care-of-address in the MMA, and a binding update message is sent to the home agent associated with the mobile terminal, wherein the binding update to the home agent includes the mobile terminal's home address and the mobile terminal's care-of-address in the MMA. Next, an IP data packet is routed from a correspondent node, destined for the mobile terminal, over

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the Internet to the mobile terminal's care-of-address in the MMA, in accordance with a Mobile IP. Thereafter, the IP data packet is routed from the MMA to the mobile terminal's point-of-attachment in the foreign Internet site, in accordance with the mobile terminal's Multicast address and a Multicast routing protocol.

5 In accordance with still another aspect of the present invention, the above-identified and other objects are achieved by a method for managing the micro mobility requirements of a mobile terminal. The method involves assigning the mobile terminal a Multicast address prior to initiating an inter-site handover of the mobile terminal from a point-of-attachment in a foreign Internet site to a point-of-attachment in the mobile terminal's home Internet site. A binding update message is then sent to a first MMA associated with the home Internet site, wherein the binding update message to the first MMA includes the home address of the mobile terminal as well as the mobile terminal's Multicast address. In addition, the mobile terminal is assigned a care-of-address in the first MMA, and a binding update message is sent to the home agent associated with the mobile terminal, wherein the binding update message to the home agent includes the mobile terminal's home address and the mobile terminal's care-of-address associated with the first MMA. Then, an IP data packet is routed from a correspondent node, destined for the mobile terminal, over the Internet to the mobile terminal's care-of-address in the first MMA, in accordance with a Mobile Internet Protocol (IP); and thereafter, the IP data packet is routed from the first MMA to the mobile terminal's point-of-attachment in the home Internet site, in accordance with the mobile terminal's Multicast address and a Multicast routing protocol.

20 In accordance with still another aspect of the present invention, the above-identified and other objects are achieved by a mobile telecommunications network capable of routing IP data packets between a mobile terminal and a correspondent node. The network includes a MMA associated with an Internet site to which the mobile terminal is attached. The network also includes means for routing an IP data packet from the correspondent node, over the Internet, to the MMA, in

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accordance with a Mobile IP and a care-of-address associated with the MMA assigned to the mobile terminal, and means for routing the IP data packet from the MMA to a present location of the mobile terminal within the Internet site, in accordance with a Multicast routing protocol and a Multicast address which has  
5 been assigned to the mobile terminal.

### BRIEF DESCRIPTION OF THE FIGURES

The objects and advantages of the present invention will be understood by reading the following detailed description in conjunction with the drawings in  
10 which:

FIG. 1 illustrates the conceptual difference between macro mobility and micro mobility;

FIG. 2 illustrates the hierarchical, double-protocol approach of the present invention;

15 FIG. 3 illustrates an exemplary format for the Multicast address assigned to each mobile terminal in accordance with the present invention;

FIG. 4 illustrates a first aspect of the present invention, wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT that undergoes an intra-site handover;

20 FIG. 5 illustrates a second aspect of the present invention, wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT after it has undergone an inter-site handover;

FIG. 6 illustrates a third aspect of the present invention, wherein the  
25 hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT that undergoes an inter-site handover;

FIG. 7 illustrates a fourth aspect of the present invention, wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT that undergoes an inter-site handover;

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FIG. 8 illustrates a fifth aspect of the present invention, wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT that undergoes an inter-site handover;

FIG. 9 illustrates yet a sixth aspect of the present invention wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT that undergoes an inter-site handover; and

FIG. 10 illustrates still a seventh aspect of the present invention wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT that undergoes an inter-site handover.

#### DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 illustrates the conceptual difference between macro mobility and micro mobility. Macro mobility, as illustrated, involves the movement of a mobile terminal (MT) from a point-of-attachment (e.g.,  $POA_A$ ) associated with a first Internet site, such as Internet site 1, to a point-of-attachment (e.g.,  $POA_C$ ) associated with a second Internet site, such as Internet site 2, wherein the movement from a first Internet site to a second Internet site is referred to herein below as an inter-site handover. In contrast, micro mobility involves the movement of a mobile terminal MT from a first point-of-attachment (e.g.,  $POA_A$ ) to a second point-of-attachment (e.g.,  $POA_B$ ), wherein both the first and the second points-of-attachment are associated with the same Internet site, for example, Internet site 1. Furthermore, the movement of the mobile terminal MT from  $POA_A$  to  $POA_B$  is referred to herein below as an intra-site handover.

As discussed above, MIPv6 does not effectively or efficiently support micro mobility. The present invention, however, provides a network solution that improves MIPv6's ability to support micro mobility, and particularly, its ability to accomplish intra-site handovers. Because mobile terminals engage in intra-site handovers at a far greater frequency than inter-site handovers, improving the efficiency and effectiveness of intra-site handovers is extremely important.

In general, the present invention more efficiently and effectively accomplishes intra-site handovers by employing a Multicast routing protocol, such as a Protocol Independent Multicast (PIM) routing protocol. However, the present invention only employs the Multicast routing protocol to support micro mobility (i.e., supporting intra-site handover and the routing of IP data packets at the Internet site level); whereas the present invention employs a Unicast routing protocol to support macro mobility (i.e., the routing of IP data packets outside or between Internet sites) in accordance with the rules and procedures of a Mobile IP, such as, though not limited to, MIPv6. The benefit of this hierarchical, double-protocol approach, wherein a Multicast routing protocol is used to support a mobile terminal's micro mobility requirements at a given Internet site, is that all intra-site handovers are completely transparent to network nodes external to the Internet site. Accordingly, there is no need for the mobile terminal MT to re-register with its home agent during an intra-site handover procedure. Moreover, there is no requirement that backbone routers along the path of an IP data packet be compatible with Multicast. In addition, because IP data packets are routed in accordance with a Multicast protocol at the Internet site level, the mobile terminal MT need not re-register with any border router, server, or the like, associated with the Internet site to which the mobile terminal is attached.

FIG. 2 illustrates the hierarchical, double-protocol approach of the present invention. As shown in FIG. 2, the "solid" line represents the path through the Internet traveled by IP data packets being routed to and from a correspondent node (CN), wherein the IP data packets traveling along this path are routed in accordance a Unicast routing protocol and the rules and procedures associated with MIPv6. The "dotted" lines, in contrast, represent potential paths through a local Internet site along which the IP data packets may travel to and from the mobile terminal MT. The IP data packets traveling along either of these two paths are routed in accordance with a Multicast routing protocol and a Multicast address that has been assigned to the mobile terminal MT.

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The present invention implements this hierarchical, double-protocol approach by employing a special Internet site level node, herein referred to as a Mobility Management Agent (MMA), also illustrated in FIG. 2. In a preferred embodiment of the present invention, the MMA is a combination of both hardware and software. Furthermore, each Internet site would employ an MMA. The primary function of the MMA is to provide a functional interface between the Unicast addressing scheme associated with MIPv6, which as stated above, is to be used for routing IP data packets outside or between Internet sites, and a Multicast addressing scheme associated with the Multicast routing protocol, which is to be used for routing IP data packets within an Internet site. The MMA provides this functionality, in part, by mapping a mobile terminal care-of-address, which is associated with the MMA itself, and the mobile terminal's Multicast address.

In accordance with a preferred embodiment of the present invention, each mobile terminal is assigned both a global Unicast address, which is referred to herein below as the mobile terminal's home address, as well as a MIPv6 Multicast address. The Multicast address, in turn, comprises a multicast prefix together with the EUI64 identifier of the mobile terminal's interface. As one skilled in the art will readily appreciate, the EUI64 identifier, is a 64-bit, IEEE global identifier code which is constructed from the hardware address of the network interface card (e.g., the PCMCIA card or Ethernet card) installed in the mobile terminal. Although the EUI64 identifier code is globally unique, it is sufficient for the purpose of the present invention that the Multicast address be unique within the immediate Internet site. FIG. 3 illustrates an exemplary format for the Multicast address to be assigned to each mobile terminal.

It should be noted that while a mobile terminal MT is attached to its home network, within its home Internet site, IP data packets are to be routed to and from the mobile terminal MT, in accordance with the mobile terminal's home address and MIPv6. It is when the mobile terminal MT travels from its home network to a point-of-attachment outside its home network that the various aspects of the present

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invention are applicable, as will now be explained in greater detail.

FIG. 4 illustrates a first aspect of the present invention, wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT that undergoes an intra-site handover from a point-of-attachment associated with its home network to a point-of-attachment associated with another subnetwork, for example, subnetwork 1, wherein subnetwork 1 is associated with the mobile terminal's home Internet site. In accordance with this first aspect of the present invention, the mobile terminal MT first registers with the home Internet site's MMA by sending a binding update to the MMA, wherein the binding update contains the mobile terminal's home address and the mobile terminal's Multicast address. In return, the mobile terminal receives a care-of-address associated with the MMA, which is sent, along with the mobile terminal's home address to the home agent in a binding update message.

Further in accordance with this first aspect of the present invention, as illustrated in FIG. 4, IP data packets being sent to the mobile terminal's home address by a correspondent node CN are routed over the Internet, as shown by line (1), in accordance with MIPv6. In the mobile terminal's home network, the IP data packets are intercepted by the mobile terminal's home agent HA. The home agent HA encapsulates the IP data packets using the mobile terminal's care-of-address associated with the MMA and then sends the encapsulated IP data packets to the MMA, as illustrated by line (2). The MMA then decapsulates the IP data packets and, thereafter, tunnels them to the mobile terminal's Multicast address in accordance with the Multicast routing protocol, as illustrated by "dashed" line (3), where tunneling involves the encapsulation, sending and de-capsulation of data packets as one skilled in the art will appreciate.

Whenever a mobile terminal MT connects itself to a point-of-attachment that is not associated with the mobile terminal's home network, the mobile terminal MT is assigned a temporary care-of-address, in accordance with MIPv6.

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This temporary care-of-address is used when sending IP data packet from the mobile node to a correspondent node CN. More specifically, when the mobile terminal MT sends an IP data packet to a correspondent node CN, the temporary care-of-address, which represents the mobile terminal's present location, is  
5 included in the source field of the IP data packet header. Also included in the IP data packet header is a Home Address Option field, in which, the mobile terminal's home address is inserted. Inserting the temporary care-of-address into the source field of the IP data packet header ensures that the IP data packet will avoid ingress filtering at intermediate routers, as one skilled in the art will  
10 appreciate.

Of course, the mobile terminal MT may continue to move about within the geographical region associated with the home Internet site. In doing so, the mobile terminal MT may undergo one or more intra-site handovers, for example, from a point-of-attachment associated with subnetwork 1 to a point-of-attachment  
15 associated with subnetwork 2. However, regardless how many intra-site handovers the mobile terminal MT undergoes, there is no need for the mobile terminal MT to re-register with the home agent HA or the MMA, as long as the mobile terminal MT remains attached to the Internet site. That is because the Multicast routing protocol ensures that IP data packets, destined for the mobile  
20 terminal MT, are delivered to the mobile terminal MT in accordance with its Multicast address, as illustrated by "dashed" line (4).

In contrast, the mobile terminal MT may move far enough away from any router associated with the various subnetworks which make up the mobile terminal's home Internet site, such that it becomes advantageous for the mobile  
25 terminal to attach to a foreign Internet site. To do so, the mobile terminal MT undergoes an inter-site handover. In general, when this occurs, the mobile terminal MT registers with the MMA associated with the foreign Internet site. The mobile terminal MT accomplishes this by sending the MMA a binding update message. wherein the binding update message contains the mobile terminal's home



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address as well as its Multicast address. In return, the mobile terminal MT is assigned a care-of-address associated with the foreign Internet site MMA. The care-of-address and the mobile terminal's home address are then registered with the mobile terminal's home agent HA.

5           FIG. 5 illustrates a second aspect of the present invention, wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT after it has undergone the inter-site handover procedure described above, wherein the mobile terminal MT is now attached to the foreign Internet site. More specifically, FIG. 5 illustrates the  
10           routing of an IP data packet from a correspondent node CN to the mobile terminal MT after the mobile terminal MT has attached itself to the foreign Internet site. As illustrated shown by line (1), the correspondent node CN initially sends IP data packets destined for the mobile terminal to the mobile terminal's home address, in accordance with MIPv6. The home agent HA intercepts the IP data packet and  
15           encapsulates it using the care-of-address associated with the foreign Internet site MMA. The home agent HA then sends the IP data packet to the MMA, as shown by line (2). The MMA, upon receiving the IP data packet, decapsulates the IP data packet, and then re-encapsulates the IP data packet using the mobile terminal's Multicast address. The MMA then sends the IP data packet to the mobile terminal  
20           MT in accordance with the Multicast routing protocol and the mobile terminal's Multicast address, as shown by "dashed" line (3) or "dashed" line (4), depend upon whether the mobile terminal MT is attached to subnetwork A and/or subnetwork B.

          In accordance with route optimization techniques, the foreign Internet site  
25           MMA may send a binding update message to the correspondent node CN, as illustrated by the line (5) in FIG. 5, wherein the binding update message contains the mobile terminal's home address and the mobile terminal's care-of-address associated with the MMA. Thereafter, the correspondent node CN can send IP data packets directly to the MMA, in accordance with MIPv6, as illustrated by line

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(6). Once again, the MMA encapsulates the IP data packets using the mobile terminal's Multicast address as the destination address. The IP data packets are then sent to the mobile terminal MT in accordance with the Multicast routing protocol and the mobile terminal's Multicast address, as illustrated by "dotted" line (3) or "dotted" line (4).

Again, the mobile terminal MT is also assigned a temporary care-of-address that is associated with its current point-of-attachment to the network. As previously stated, this temporary care-of-address is used as the source address when the mobile terminal MT sends IP data packets to a correspondent node. Doing so ensures that the IP data packets being sent by the mobile terminal MT avoid ingress filtering at intermediate routers.

The benefits and other advantages associated with this second aspect of the present invention are most evident when the mobile terminal MT undergoes one or more intra-site handovers within the same foreign Internet site, for example, from the subnetwork associated with router A to the subnetwork associated with router B. That is because intra-site handovers are transparent to the network nodes external to the foreign Internet site, as explained above. Accordingly, there is no need to re-register with the home agent HA. Likewise, there is no need to re-register with the MMA. Avoiding these re-registration steps significantly reduces overall network overhead and the time required to complete a handover procedure. Another, perhaps more significant benefit, is that a mobile terminal may receive IP data packets from different networks at the same time. It is noted, however, that while the mobile terminal MT is able to avoid re-registering with its home agent HA, as well as the MMA associated with the foreign Internet site, it does have to send a Multicast Join Request message to the router associated with the subnetwork to which the mobile terminal MT is attempting to attach, for example, router B.

As the mobile terminal MT moves about within the geographic domain associated with the foreign Internet site, it may, of course, receive IP data packets

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from different routers (i.e., from different networks). However, it is currently possible to transmit IP data packets through one router at a time. Therefore, when it comes time to request a handover (e.g., when the signal quality associated with the communications link between the mobile terminal MT and the router through which it is currently attached drops below a certain signal quality threshold), the mobile terminal MT should request attachment to the subnetwork associated with the router that best meets its needs.

One way the mobile terminal MT assures that it chooses the router that best suits its needs, is to monitor the router advertisements broadcast by each router proximately located to the mobile terminal MT. The mobile terminal MT can use these router advertisements to derive an average measure of signal strength for each router. The router exhibiting the highest signal strength may be the one that best suites the mobile terminal's requirements. However, it will be understood that in choosing a router, factors other than signal strength may be considered, such as bandwidth capability, congestion, delay, various geographical factors, cost and available services.

It should be noted that each router advertisement identifies the corresponding router as well as the address associated with the corresponding MMA, that is, the MMA associated with the Internet site. During a handover procedure, a mobile terminal MT can use this information to determine if the impending handover is an intra-site handover or an inter-site handover. For example, if the mobile terminal MT selects a router whose router advertisement contains the address of the MMA associated with the present Internet site, the handover will be an intra-site handover. In contrast, if the mobile terminal MT selects a router whose router advertisement contains the address of a MMA associated with a different Internet site, the handover will be an inter-site handover.

FIG. 6 now illustrates a third aspect of the present invention, wherein the hierarchical, double-protocol technique is used to support the micro mobility

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requirements of a mobile terminal MT that undergoes an inter-site handover from a subnetwork A associated with router A, which in turn is associated with a first foreign Internet site A, to a subnetwork B associated with router B, which in turn is associated with a second foreign Internet site B. As stated above, the mobile terminal MT recognizes that it has or is about to undergo an inter-site handover because the router advertisement broadcast by router B contains the address of a new MMA (i.e., MMA<sub>2</sub>).

In accordance with this third aspect of the present invention, the mobile terminal MT registers with MMA<sub>2</sub>, as illustrated by line (1) in FIG. 6, wherein registration involves sending a binding update message to MMA<sub>2</sub> which contains the home address and the Multicast address of the mobile terminal MT. In return, the mobile terminal MT is assigned a care-of-address associated with MMA<sub>2</sub>. In addition, the mobile terminal MT sends a Multicast Join Request message to router B. However, at this point, the mobile terminal MT continues to receive IP data packets from a correspondent node CN through MMA<sub>1</sub>, as shown by lines (2) and (3).

In addition to registering with MMA<sub>2</sub>, the mobile terminal MT also registers with its home agent HA, as illustrated by line (4). Registration with the home agent HA involves sending a binding update message that contains the mobile terminal's home address and the mobile terminal's care-of-address associated with MMA<sub>2</sub>. Once the mobile terminal MT registers with its home agent HA, the home agent HA can tunnel IP data packets, destined for the mobile terminal MT, over the Internet to MMA<sub>2</sub> rather than MMA<sub>1</sub>, in accordance with MIPv6 and the mobile terminal's care-of-address associated with MMA<sub>2</sub>. MMA<sub>2</sub> then tunnels the IP data packets to the mobile terminal MT in accordance with the Multicast routing protocol and the mobile terminal's Multicast address, as illustrated by "dashed" line (5).

Eventually, the mobile terminal MT de-registers with MMA<sub>1</sub>, as illustrated by line (6) in FIG. 6. In accordance with a preferred embodiment of the present

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invention, de-registration includes a request that  $MMA_1$  tunnel IP data packets from a correspondent node CN to the mobile terminal MT, via  $MMA_2$ , for a certain period of time, as illustrated by line (7). This, of course, assumes that correspondent node CN was sending IP data packets to the mobile terminal MT in accordance with route optimization techniques. However, upon receiving an IP data packet from  $MMA_1$  for the mobile terminal MT,  $MMA_2$ , in addition to tunneling the IP data packet to the mobile terminal MT in accordance with the Multicast routing protocol and the mobile terminal's Multicast address, sends a binding update message to the correspondent node CN, as illustrated by line (8). In doing so, the correspondent node CN can continue to employ route optimization through  $MMA_2$ , rather than through  $MMA_1$ , as shown by line (9).

As previously explained, the mobile terminal MT may continue to move about within a geographic region associated with foreign Internet site B, and in so doing, undergo numerous intra-site handover procedures. However, as long as the mobile terminal MT remains connected to foreign Internet site B, the mobile terminal MT need not re-register with its home agent HA. Furthermore, the mobile terminal MT need not re-register with  $MMA_2$ , since the mobile terminal's Multicast address does not change.

FIG. 7 illustrates a fourth aspect of the present invention, wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT that undergoes an inter-site handover from a subnetwork A associated with router A, which in turn is associated with a foreign Internet site, to a subnetwork B associated with router B, which in turn is associated with the mobile terminal's home network. In accordance with this fourth aspect of the present invention, the mobile terminal MT requests a handover from router A to router B based on the signal strength of the router advertisements it received from router B, and/or other factors described above. Of course, the mobile terminal MT recognizes that router B is associated with its home network because the router advertisements broadcast by router B contain the mobile

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terminal's home network prefix.

The mobile terminal MT then de-registers with its home agent HA, by sending the home agent HA a binding update message that includes the mobile terminal's home address. The mobile terminal MT also de-registers with the MMA associated with the foreign network. The request to de-register with the MMA is illustrated by line (1). Again, de-registering with the MMA includes a request that the MMA continue to tunnel IP data packets received from any correspondent nodes, as illustrated by line (2), to the mobile terminal for a certain period of time, as illustrated by "dashed" line (3). Upon receiving an IP data packet from the correspondent node CN, via the MMA, the mobile terminal MT may send a binding update message to the correspondent node, as illustrated by line (4), wherein the binding update message informs the correspondent node CN to thereafter route IP data packets to the mobile terminal's home address, as shown by line (5).

FIG. 8 illustrates a fifth aspect of the present invention, wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT that undergoes an inter-site handover from a subnetwork A associated with router A, wherein subnetwork A and router A are, in turn, associated with a foreign Internet site, to a subnetwork B associated with router B, wherein subnetwork B and router B are, in turn, associated with the mobile terminal's home Internet site. However, subnetwork B is not the mobile terminal's home network. In accordance with this fifth aspect of the present invention, the mobile terminal MT requests a handover from router A to router B based on the signal strength of the router advertisements it receives from router B, and/or other factors described above.

The mobile terminal MT then registers with the MMA associated with its home Internet site (i.e.,  $MMA_2$ ). The mobile terminal MT registers with  $MMA_2$  by sending  $MMA_2$  a binding update message that contains the mobile terminal's home address and the mobile terminal's Multicast address. The sending of the

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binding update message is illustrated in FIG. 8 by line (1). In return, the mobile terminal MT is assigned a care-of-address associated with  $MMA_2$ . In addition to sending a binding update to  $MMA_2$ , the mobile terminal MT also sends a Multicast Join Request message to router B.

5       The mobile terminal MT also registers with its home agent HA, by sending the home agent HA a binding update message that contains its home address and its care-of-address associated with  $MMA_2$ . The Sending of the binding update message to the home agent HA is illustrated in FIG. 8 by line (2). Thereafter, the home agent HA can tunnel IP data packets from any correspondent nodes, such as  
10       correspondent node CN, destined for the mobile terminal MT, to  $MMA_2$  rather than the  $MMA_1$  (i.e., the MMA through which the mobile terminal MT was previously receiving IP data packets).  $MMA_2$  can then tunnel the IP data packets to the mobile terminal MT in accordance with the Multicast routing protocol and the mobile terminal's Multicast address, as illustrated by "dashed" line (3).

15       Further in accordance with the fifth aspect of the present invention, the mobile terminal MT de-registers with the MMA through which it was previous communicating (i.e.,  $MMA_1$ ). This de-registration message is illustrated in FIG. 8 by line (4). Included with the de-registration message is a request that  $MMA_1$  tunnel IP data packets from any correspondent nodes CN to  $MMA_2$  for a certain  
20       period of time. This assumes, of course, that the correspondent node CN is employing route optimization techniques in sending IP data packets to the mobile terminal MT. The temporary tunneling of IP data packets from  $MMA_1$  to  $MMA_2$  is illustrated by line (5).

25       Upon receiving an IP data packet from  $MMA_1$ , destined for the mobile terminal MT,  $MMA_2$  tunnels the IP data packet to the mobile terminal MT in accordance with the Multicast routing protocol and the mobile terminal's Multicast address, as illustrated by "dashed" line (3). In addition,  $MMA_2$  may send a binding update message to the correspondent node CN, as shown by line (6), wherein the binding update message contains the mobile terminal's home address

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and the mobile terminal's care-of-address in  $MMA_2$ . Thereafter, the correspondent node CN can employ route optimization techniques to send IP data packets destined for the mobile terminal MT directly to  $MMA_2$  in accordance with MIPv6, as illustrated by line (7).  $MMA_2$  then tunnels the IP data packets to the mobile terminal MT in accordance with the Multicast routing protocol and the mobile terminal's Multicast address, as illustrated by "dashed" line (3). It should be noted that "solid" line (8) and "dashed" line (9) represent the routing of IP data packets to the mobile terminal MT prior to the inter-site handover, wherein the "dashed" line (9) indicates that IP data packets are being routed in accordance with the Multicast routing protocol and the mobile terminal's Multicast address.

Once again, the benefits and other advantages associated with the fifth aspect of the present invention are most evident as the mobile terminal MT moves about within the geographic region associated with its home Internet site, so that it undergoes one or more intra-site handovers to routers associated with subnetworks that are not the mobile terminal's home network. For example, if the mobile terminal MT undergoes an intra-site handover, there is no need for the mobile terminal MT to re-register with the home agent HA. Nor is there any need for the mobile terminal MT to re-register with  $MMA_2$ . As previously stated, avoiding these re-registration procedures during handover saves time and network overhead, and it generally speeds up the handover procedure, thereby improving micro mobility.

As stated above, a mobile terminal MT presently attached to its home Internet site may move far enough away from any routers associated with its home Internet site such that it becomes advantageous to attach to a foreign Internet site. FIG. 9 illustrates yet a sixth aspect of the present invention wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT that undergoes an inter-site handover from a router A associated with a subnetwork A other than the mobile terminal's home network, wherein subnetwork A is, nevertheless, associated with the mobile



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terminal's home Internet site, to a router B associated with subnetwork B in the foreign Internet site.

In accordance with this sixth aspect of the present invention, the mobile terminal MT requests a handover from router A to router B based on the signal strength of the router advertisements it receives from router B, and/or other factors described above. The mobile terminal MT then registers with the MMA associated with the foreign Internet site (i.e.,  $MMA_2$ ). Registration with  $MMA_2$  involves sending a binding update message to  $MMA_2$ , which contains the mobile terminal's home address as well as the mobile terminal's Multicast address. Sending the binding update message to  $MMA_2$  is illustrated in FIG. 9 by line (1). In return, the mobile terminal MT is assigned a care-of-address associated with  $MMA_2$ . In addition, the mobile terminal MT sends a Multicast Join Request message to router B.

The mobile terminal MT also registers with its home agent HA. Registration with the home agent HA involves sending a binding update message to the home agent HA, wherein the binding update message contains the mobile terminal's home address and the mobile terminal's care-of-address associated with  $MMA_2$ . Sending a binding update message to the home agent HA is illustrated in FIG. 9 by line (2). Herein after, the home agent HA is capable of tunneling IP data packets, destined for the mobile terminal MT, to  $MMA_2$  in accordance with MIPv6 and the care-of-address associated with  $MMA_2$ .  $MMA_2$  can then tunnel the IP data packets to the mobile terminal MT in accordance with the Multicast routing protocol and the mobile terminal's Multicast address, as illustrated by "dashed" line (3).

Further in accordance with the sixth aspect of the present invention, the mobile terminal MT de-registers with  $MMA_1$ . The process of de-registering with  $MMA_1$  is illustrated in FIG. 9 by line (4). Included in the de-registration process is a request that  $MMA_1$  tunnel IP data packets destined for the mobile terminal MT, from any correspondent node CN, to  $MMA_2$  in accordance with MIPv6 for a

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certain period of time. Again, this assumes that the correspondent node CN sending the IP data packets was employing route optimization techniques. The tunneling of IP data packets from  $MMA_1$  to  $MMA_2$  is illustrated by line (5).

5 Upon receiving IP data packets from  $MMA_1$ , destined for the mobile terminal MT,  $MMA_2$  tunnels the IP data packets to the mobile terminal MT in accordance with the Multicast routing protocol and the mobile terminal's Multicast address, as illustrated by "dashed" line (3). Furthermore,  $MMA_2$  sends a binding update message to the correspondent node CN, as illustrated by line (6), wherein the binding update message contains the home address of the mobile terminal MT and the mobile terminal's care-of-address associated with  $MMA_2$ . Thereafter, the  
10 correspondent node CN can route IP data packets destined for the mobile terminal MT, to  $MMA_2$  directly, as shown by line (7), in accordance with MIPv6 and the care-of-address associated with  $MMA_2$ .  $MMA_2$  will then tunnel the IP data packets to the mobile terminal MT in accordance with the Multicast routing  
15 protocol and the mobile terminal's Multicast address, as illustrated by "dashed" line (3). It should be noted that line (8) represents the routing path of IP data packets prior to the inter-site handover.

Again, the benefits and other advantages associated with the sixth aspect of the present invention are most evident when the mobile terminal MT continues to  
20 move about within the geographic region associated with the foreign Internet site, such that the mobile terminal MT undergoes one or more intra-site handovers between routers associated with the foreign Internet site. For example, when the mobile terminal MT does, in fact, undergo an intra-site handover within the foreign Internet site, there is no need for the mobile terminal MT to re-register  
25 with its home agent HA. Nor is there any need for the mobile terminal MT to re-register with  $MMA_2$ . As previously stated, avoiding these re-registration procedures during handover saves time and network overhead, and it generally speeds up the handover procedure.

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FIG. 10 illustrates yet a seventh aspect of the present invention wherein the hierarchical, double-protocol technique is used to support the micro mobility requirements of a mobile terminal MT that undergoes an inter-site handover from a router A, that is associated with the mobile terminal's home network, to a router B associated with a foreign Internet site. In accordance with this seventh aspect of the present invention, the mobile terminal MT requests a handover from router A to router B based on the signal strength of the router advertisements it receives from router B, and/or other factors described above.

Again, the mobile terminal MT then registers with the MMA associated with the foreign network. Registration involves sending a binding update message to the MMA, wherein the binding update message contains the mobile terminal's home address as well as the mobile terminal's Multicast address. Sending the binding update message to the MMA is illustrated in FIG. 10 by line (1). In return, the mobile terminal MT is assigned a care-of-address associated with the MMA. In addition, the mobile terminal MT sends a Multicast Join Request message to router B.

The mobile terminal MT also registers with its home agent HA. Registration with the home agent HA involves sending the home agent a binding update message that contains the mobile terminal's home address and the mobile terminal's care-of-address associated with the MMA. Sending the binding update message to the home agent is illustrated in FIG. 10 by line (2). Herein after, the home agent can, upon intercepting IP data packets destined for the mobile terminal MT, tunnel the intercepted IP data to the MMA in accordance with the mobile terminal's care-of-address associated with the MMA and in accordance with MIPv6. Line (3) in FIG. 10 represents IP data packets being tunneled from the home agent to the MMA, in accordance with MIPv6.

Upon receiving the IP data packets from the home agent, the MMA tunnels the IP data packets to the mobile terminal MT in accordance with the Multicast routing protocol and the mobile terminal's Multicast address, as indicated by

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“dashed” line (4) in FIG. 10. In addition, the MMA sends a binding update message to the correspondent node CN, as illustrated by line (5), wherein the binding update message contains the mobile terminal’s home address and the care-of-address associated with the MMA. In so doing, the correspondent node CN can begin sending IP data packets, destined for the mobile terminal MT, directly to the MMA, as illustrated by line (6), in accordance with MIPv6. Again, the MMA then tunnels the packets to the mobile terminal MT, as illustrated by “dashed” line (4), in accordance with the Multicast routing protocol and the mobile terminal’s Multicast address. It should be noted that line (7) represents the routing path of IP data packets prior to the inter-site handover.

As was the case for each of the previously described aspects of the present invention, the benefits and other advantages associated with the seventh aspect of the present invention are most evident when the mobile terminal MT moves to a new point-of-attachment in the foreign Internet site, such that it undergoes an intra-site handover. Because the Multicast address of the mobile terminal MT does not change and because the Multicast routing protocol ensures that the IP data packets will be properly tunneled to the mobile terminal MT from the corresponding MMA, there is no need for the mobile terminal MT to re-register with its home agent HA during the intra-site handover. Nor is there any need for the mobile terminal MT to re-register with the MMA. Consequently, the intra-site handover, and micro mobility in general, are accomplished in a far more efficient and effective manner.

The present invention has been described with reference to a number aspects and various exemplary embodiments. However, it will be readily apparent to those skilled in the art that it is possible to embody the invention in specific forms other than those described above without departing from the spirit of the invention. The various aspects and exemplary embodiments are illustrative, and they should not be considered restrictive in any way. The scope of the invention is given by the appended claims, rather than the preceding description, and all

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variations and equivalents thereof which fall within the range of the claims are intended to be embraced therein.

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**WHAT IS CLAIMED IS:**

1. In a mobile telecommunications network, a method for routing Internet Protocol (IP) data packets between a mobile terminal and a correspondent node,  
5 said method comprising the steps of:  
    routing an IP data packet from the correspondent node, over the Internet, to a mobility management agent (MMA) associated with the Internet site to which the mobile terminal is attached, in accordance with a Mobile Internet Protocol (Mobile IP) and a network address associated with the MMA; and  
10      routing the IP data packet from the MMA to a present location of the mobile terminal in the Internet site, in accordance with a Multicast routing protocol and a Multicast address which has been assigned to the mobile terminal.
2. The method of claim 1, wherein said step of routing the IP data packet  
15 from the correspondent node, over the Internet, to the MMA, in accordance with a Mobile IP and the network address associated with the MMA, comprises the steps of:  
    routing the IP data packet to a home address assigned to the mobile terminal;  
20      intercepting the IP data packet at the mobile terminal's home network; and  
    tunneling the IP data packet from the mobile terminal's home network to the MMA in accordance with the Mobile IP and the network address associated with the MMA.
- 25 3. The method of claim 1 further comprising the step of:  
    receiving the IP data packet at the MMA, wherein the IP data packet identifies the mobile terminal by a home address associated with the mobile terminal;  
    determining the Multicast address associated with the mobile terminal based

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on mapping data contained in the MMA, wherein the mapping data relates the Multicast address of the mobile terminal to the home address of the mobile terminal; and

5 encapsulating the IP data packet using the mobile terminal's Multicast address.

4. The method of claim 3, wherein said step of routing the IP data packet from the MMA to the present location of the mobile terminal in the Internet site, in accordance with the Multicast routing protocol and the mobile terminal's Multicast  
10 address comprises the step of:

sending the encapsulated IP data packet to the mobile terminal in accordance with the Multicast routing protocol.

5. The method of claim 1, wherein the mobile terminal's home address is a  
15 Unicast address.

6. The method of claim 1, wherein the mobile terminal is a visiting mobile terminal at the Internet site.

20 7. The method of claim 1, wherein the Multicast routing protocol is a Protocol Independent Multicast (PIM) routing protocol

8. The method of claim 1, wherein the Mobile IP is the Mobile IP version 6.

25 9. The method of claim 1, wherein the Mobile IP is the Mobile IP version 4.

10. In a mobile telecommunications network, a method for managing the micro mobility requirements of a mobile terminal comprising the steps of:

assigning the mobile terminal a Multicast address;

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initiating a first intra-site handover of the mobile terminal from a first subnetwork to a second subnetwork, wherein the first subnetwork is the mobile terminal's home subnetwork, and wherein both the first subnetwork and the second subnetwork are associated with the mobile terminal's home Internet site;

- 5        sending a binding update message to a home agent associated with the mobile terminal, wherein the binding update message to the home agent contains information including a home address associated with the mobile terminal; and
- sending a binding update message to a mobility management agent (MMA) associated with the home Internet site, wherein the binding update message to the
- 10     MMA contains information including the mobile terminal's Multicast address.

11.    The method of claim 10 further comprising the steps of:

      sending an IP data packet destined for the mobile terminal to the MMA, in accordance with a Mobile Internet Protocol (IP); and

- 15        tunneling the IP data packet from the MMA to the mobile terminal located at a point-of-attachment in the second subnetwork, in accordance with a Multicast routing protocol and the mobile terminal's Multicast address.

12.    The method of claim 11, wherein said step of sending the IP data packet

20     destined for the mobile terminal to the MMA, in accordance with the Mobile IP comprises the steps of:

      routing the IP data packet over the Internet from a correspondent node to the mobile terminal's home address;

      intercepting the IP data packet at the home agent; and

- 25        tunneling the IP data packet from the home agent to the MMA.

13.    The method of claim 10, wherein the binding update message to the home agent further includes a care-of-address associated with the MMA.



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14. The method of claim 10, wherein the binding update message to the MMA further includes the mobile terminal's home address.

15. The method of claim 10 further comprising the step of:

5 initiating another intra-site handover of the mobile terminal to a third subnetwork associated with the mobile terminal's home Internet site;  
routing an IP data packet to the MMA in accordance with the Mobile IP and the binding update information sent to the home agent during the first intra-site handover; and

10 routing the IP data packet from the MMA to the mobile terminal located at a point-of-attachment in the third subnetwork, in accordance with the Multicast routing protocol and the mobile terminal's Multicast address contained in the binding update message sent to the MMA during the first intra-site handover.

15 16. The method of claim 10, wherein the Multicast routing protocol is a Protocol Independent Multicast (PIM) routing protocol.

17. The method of claim 10, wherein the mobile terminal's home address is a Unicast address.

20

18. The method of claim 10, wherein the Mobile IP is the Mobile IP version 6.

19. In a mobile telecommunications network, a method for managing the micro mobility requirements of a mobile terminal comprising the steps of:

25 assigning the mobile terminal a Multicast address;  
initiating an inter-site handover of the mobile terminal to a point-of-attachment associated with a foreign Internet site;  
sending a binding update message to a mobility management agent (MMA) associated with the foreign Internet site, wherein the binding update message to the

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MMA includes a home address for the mobile terminal and the mobile terminal's Multicast address;

assigning the mobile terminal a care-of-address in the MMA;

5 sending a binding update message to a home agent associated with the mobile terminal, wherein the binding update to the home agent includes the mobile terminal's home address and the mobile terminal's care-of-address in the MMA;

routing an IP data packet from a correspondent node, destined for the mobile terminal, over the Internet to the mobile terminal's care-of-address in the MMA, in accordance with a Mobile Internet Protocol (IP); and

10 routing the IP data packet from the MMA to the mobile terminal's point-of-attachment in the foreign Internet site, in accordance with the mobile terminal's Multicast address and a Multicast routing protocol.

20. The method of claim 19, wherein said step of routing the IP data packet, destined for the mobile terminal, to the mobile terminal's care-of-address in the MMA, in accordance with the Mobile IP comprises the steps of:

15 sending the IP data packet from a correspondent node, over the Internet, to the mobile terminal's home address;

intercepting the IP data packet at the home agent;

20 encapsulating the IP data packet using the mobile terminal's care-of-address in the MMA; and

sending the IP data packet from the home agent to the MMA.

21. The method of claim 19 further comprising the step of:

25 sending a binding update message to a correspondent node, wherein the binding update message to the correspondent node includes the mobile terminal's home address and the mobile terminal's care-of-address associated in the MMA.

22. The method of claim 21, wherein said step of routing the IP data packet,

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destined for the mobile terminal, to the mobile terminal's care-of-address in the MMA, in accordance with the Mobile IP comprises the step of:

5 directly routing the IP data packet from a correspondent node, over the Internet, to the mobile terminal's care-of-address in the MMA, in accordance with the Mobile IP.

23. The method of claim 19 further comprising the steps of:

10 initiating an intra-site handover of the mobile terminal from a current point-of-attachment in the foreign Internet site to a new point-of-attachment in the foreign Internet site;

routing a second IP data packet from the correspondent node, destined for the mobile terminal, to the mobile terminal's care-of-address in the MMA, in accordance with the Mobile IP; and

15 routing the IP data packet from the MMA to the mobile terminal's new point-of-attachment in the foreign Internet site, in accordance with the mobile terminal's Multicast address and the Multicast routing protocol.

24. The method of claim 19 further comprising the step of:

20 sending a de-registration message to a previous MMA, wherein the previous MMA is associated with a previous Internet site to which the mobile terminal was attached.

25. The method of claim 24, wherein said step of sending the de-registration message to the previous MMA comprises the step of:

25 requesting that the previous MMA tunnel IP data packets, destined for the mobile terminal, to the mobile terminal's care-of-address in the MMA associated with the foreign Internet site to which the mobile terminal is presently attached, for a certain period of time.

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26. The method of claim 25 further comprising the steps of:  
tunneling IP data packets, destined for the mobile terminal, from the  
previous MMA to the mobile terminal's care-of-address in the MMA associated  
with the foreign Internet site to which the mobile terminal is presently attached, for  
5 a certain period of time, in accordance with the Mobile IP; and  
tunneling the IP data packets from the MMA, associated with the foreign  
Internet site to which the mobile terminal is presently attached, to the mobile  
terminal in accordance with the Multicast routing protocol and the mobile  
terminal's Multicast address.
- 10 27. The method of claim 19, wherein the Mobile IP is the Mobile IP version 6.
28. In a mobile telecommunications network, a method for managing the micro  
mobility requirements of a mobile terminal comprising the steps of:  
15 assigning the mobile terminal a Multicast address;  
initiating an inter-site handover of the mobile terminal from a point-of-  
attachment in a foreign Internet site to a point-of-attachment in the mobile  
terminal's home Internet site;  
sending a binding update message to a first mobility management agent  
20 (MMA) associated with the home Internet site, wherein the binding update  
message to the first MMA includes a home address for the mobile terminal and the  
mobile terminal's Multicast address;  
assigning the mobile terminal a care-of-address in the first MMA;  
sending a binding update message to a home agent associated with the  
25 mobile terminal, wherein the binding update message to the home agent includes  
the mobile terminal's home address and the mobile terminal's care-of-address  
associated with the first MMA;  
routing an IP data packet from a correspondent node, destined for the  
mobile terminal, over the Internet to the mobile terminal's care-of-address in the

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first MMA, in accordance with a Mobile Internet Protocol (IP); and

routing the IP data packet from the first MMA to the mobile terminal's point-of-attachment in the home Internet site, in accordance with the mobile terminal's Multicast address and a Multicast routing protocol.

5

29. The method of claim 28, wherein said step of routing the IP data packet from a correspondent node, destined for the mobile terminal, over the Internet to the mobile terminal's care-of-address in the first MMA, in accordance with the Mobile IP comprises the steps of:

10

sending the IP data packet from the correspondent node, over the Internet, to the mobile terminal's home address;

intercepting the IP data packet at the home agent;

encapsulating the IP data packet using the mobile terminal's care-of-address in the first MMA; and

15

sending the IP data packet from the home agent to the first MMA.

30. The method of claim 28 further comprising the step of:

sending a binding update message to the correspondent node, wherein the binding update message to the correspondent node includes the mobile terminal's home address and the mobile terminal's care-of-address in the first MMA.

20

31. The method of claim 28 further comprising the steps of:

initiating an intra-site handover of the mobile terminal from a current point-of-attachment in the home Internet site to a new point-of-attachment in the home Internet site;

25

routing a second IP data packet from the correspondent node, destined for the mobile terminal, to the mobile terminal's care-of-address in the first MMA, in accordance with the Mobile IP; and

routing the IP data packet from the first MMA to the mobile terminal's new

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point-of-attachment in the home Internet site, in accordance with the mobile terminal's Multicast address and the Multicast routing protocol.

32. The method of claim 28 further comprising the step of:

5        sending a de-registration message to a previous MMA, wherein the previous MMA is associated with a foreign Internet site to which the mobile terminal was previously attached.

33. The method of claim 32, wherein said step of sending the de-registration message to the previous MMA comprises the step of:

10        requesting that the previous MMA tunnel IP data packets, destined for the mobile terminal, to the mobile terminal's care-of-address in the first MMA, for a certain period of time.

15        34. The method of claim 33 further comprising the steps of:

      tunneling IP data packets, destined for the mobile terminal, from the previous MMA to the mobile terminal's care-of-address in the first MMA, for a certain period of time, in accordance with the Mobile IP; and

20        tunneling the IP data packets from the first MMA to the mobile terminal in accordance with the Multicast routing protocol and the mobile terminal's Multicast address.

35. The method of claim 28 wherein the Mobile IP is the Mobile IP version 6.

25        36. A mobile telecommunications network capable of routing Internet Protocol (IP) data packets between a mobile terminal and a correspondent node, said network comprising:

      a mobility management agent (MMA) associated with an Internet site to which the mobile terminal is attached;

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means for routing an IP data packet from the correspondent node, over the Internet, to the MMA, in accordance with a Mobile Internet Protocol (IP) and a care-of-address associated with the MMA assigned to the mobile terminal; and

5 means for routing the IP data packet from the MMA to a present location of the mobile terminal within the Internet site, in accordance with a Multicast routing protocol and a Multicast address which has been assigned to the mobile terminal.

37. The network of claim 1, wherein said means for routing the IP data packet from the correspondent node, over the Internet, to the MMA, in accordance with a  
10 Mobile IP and the mobile terminal's care-of-address in the MMA, comprises:

means for routing the IP data packet to a home address assigned to the mobile terminal;

a home agent of the mobile terminal for intercepting the IP data packet at the mobile terminal's home network; and

15 means for tunneling the IP data packet to the MMA in accordance with Mobile IP and the mobile terminal's care-of-address in the MMA.

38. The network of claim 36 further comprising:

20 means for receiving the IP data packet at the MMA, wherein the IP data packet identifies the mobile terminal by a home address associated with the mobile terminal;

mapping means in the MMA for determining the Multicast address associated with the mobile terminal based on the mobile terminal's home address; and

25 means for encapsulating the IP data packet using the mobile terminal's Multicast address.

39. The network of claim 38, wherein said means for routing the IP data packet from the MMA to the present location of the mobile terminal within the Internet

-38-

site, in accordance with the Multicast routing protocol and the mobile terminal's Multicast address comprises:

means for sending the encapsulated IP data packet to the mobile terminal in accordance with the Multicast routing protocol.

5

40. The network of claim 36, wherein the mobile terminal's home address is a Unicast address.

10

41. The network of claim 36, wherein the mobile terminal is a visiting mobile terminal at the Internet site.

42. The network of claim 36, wherein the Multicast routing protocol is a Protocol Independent Multicast (PIM) routing protocol.

15

43. The network of claim 36, wherein the Mobile IP is the Mobile IP version 6.



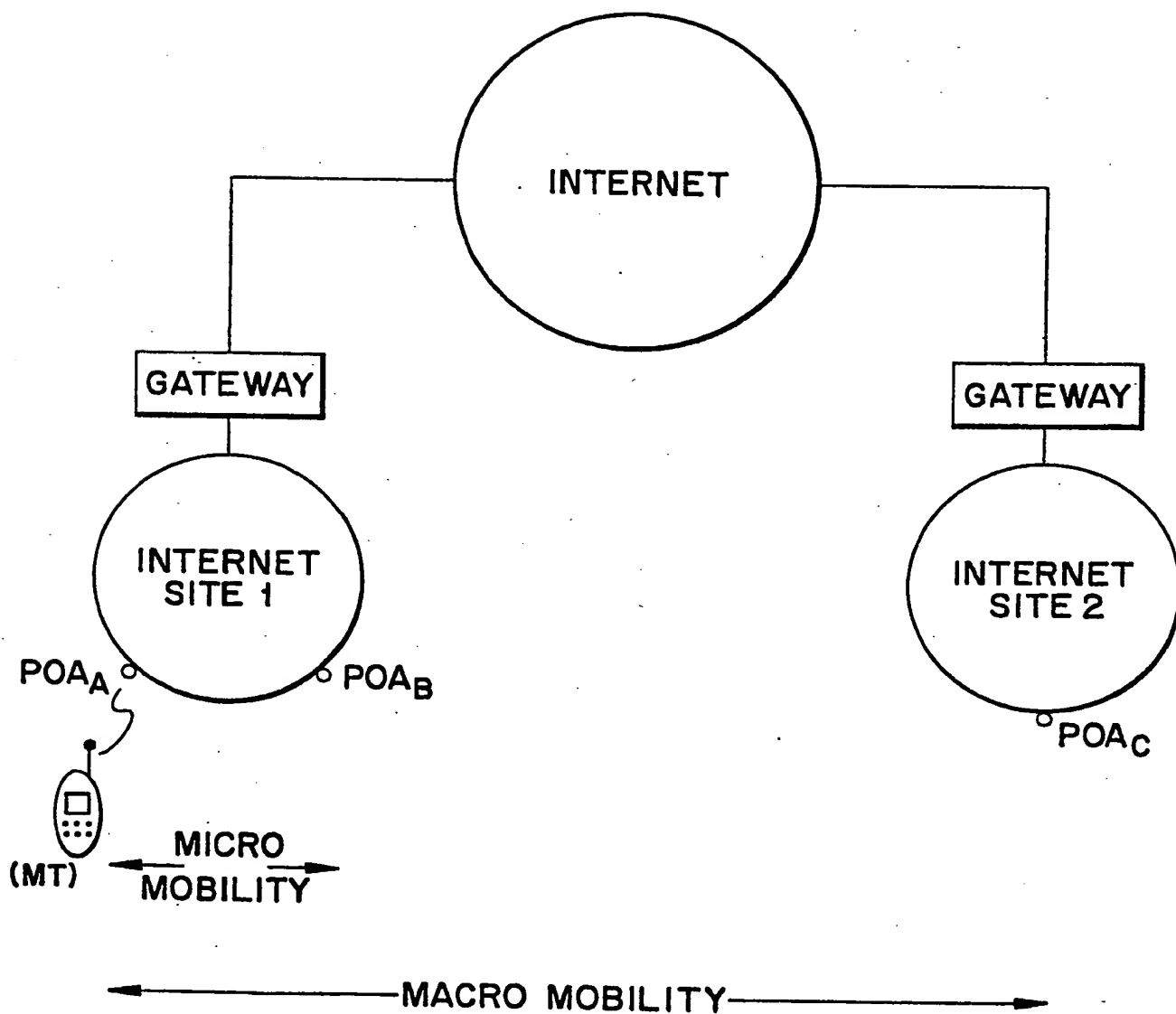


FIG. 1

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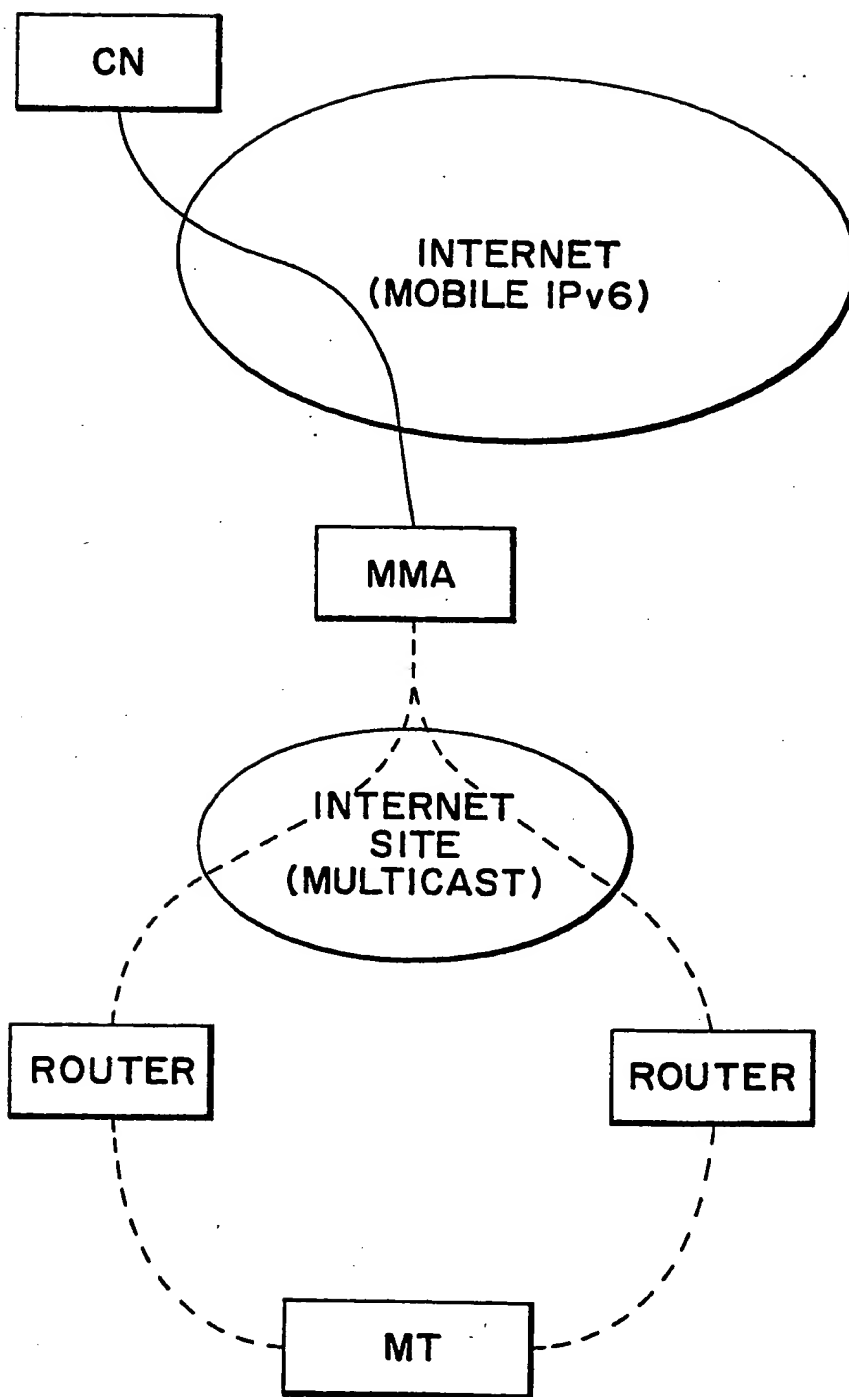


FIG. 2

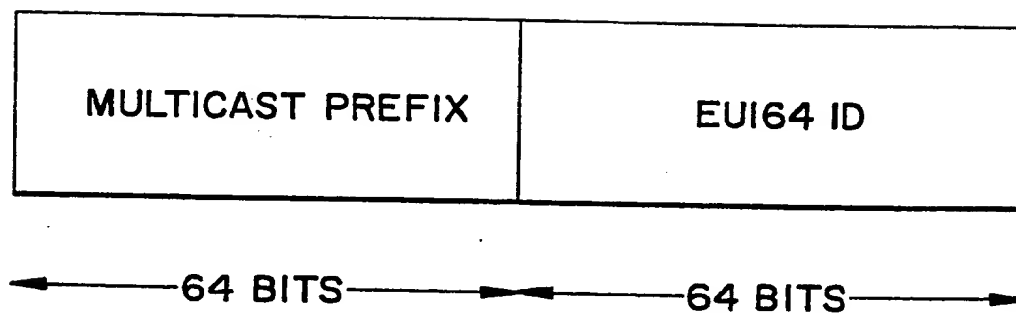


FIG. 3

FIG. 4

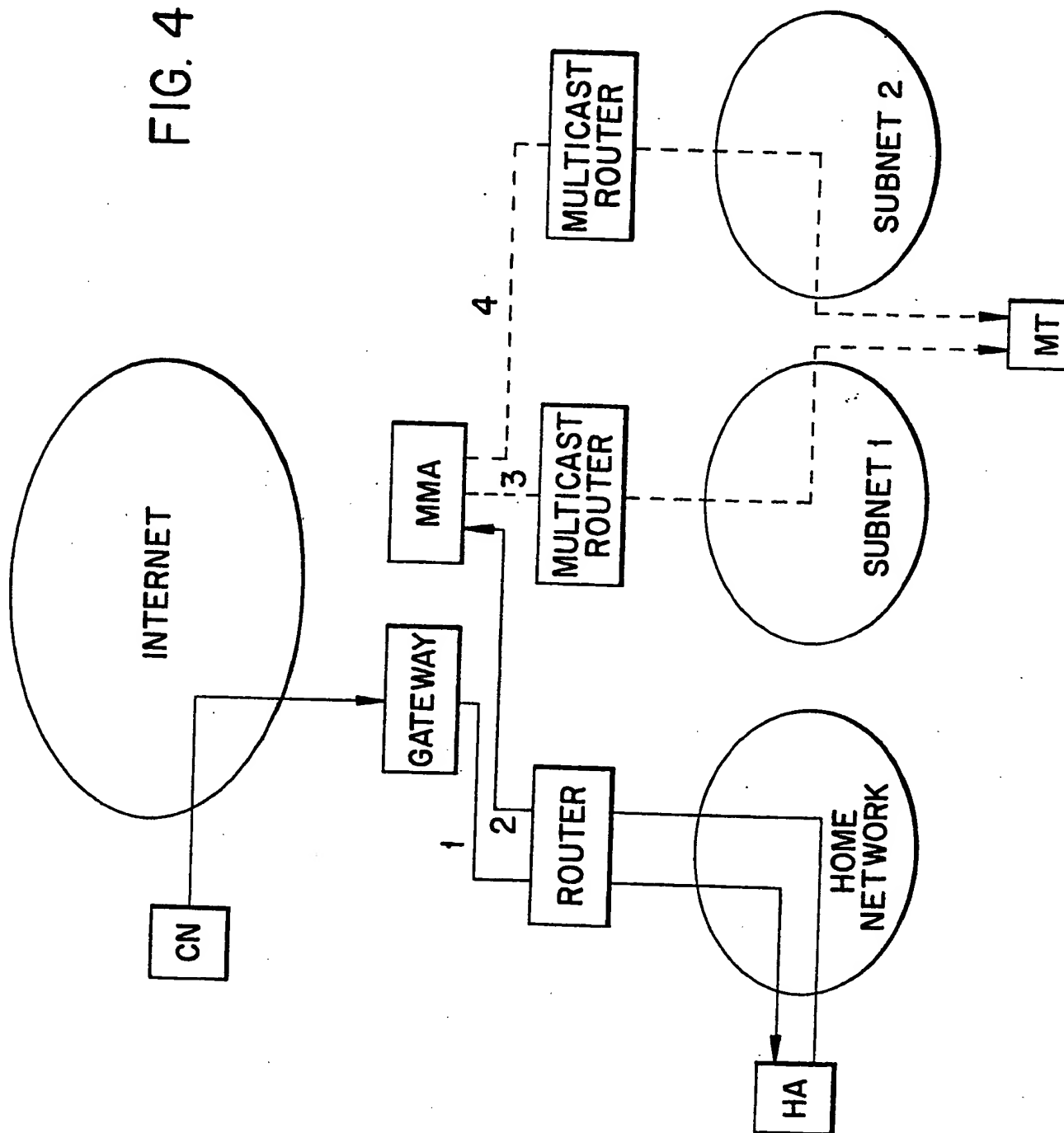


FIG. 5

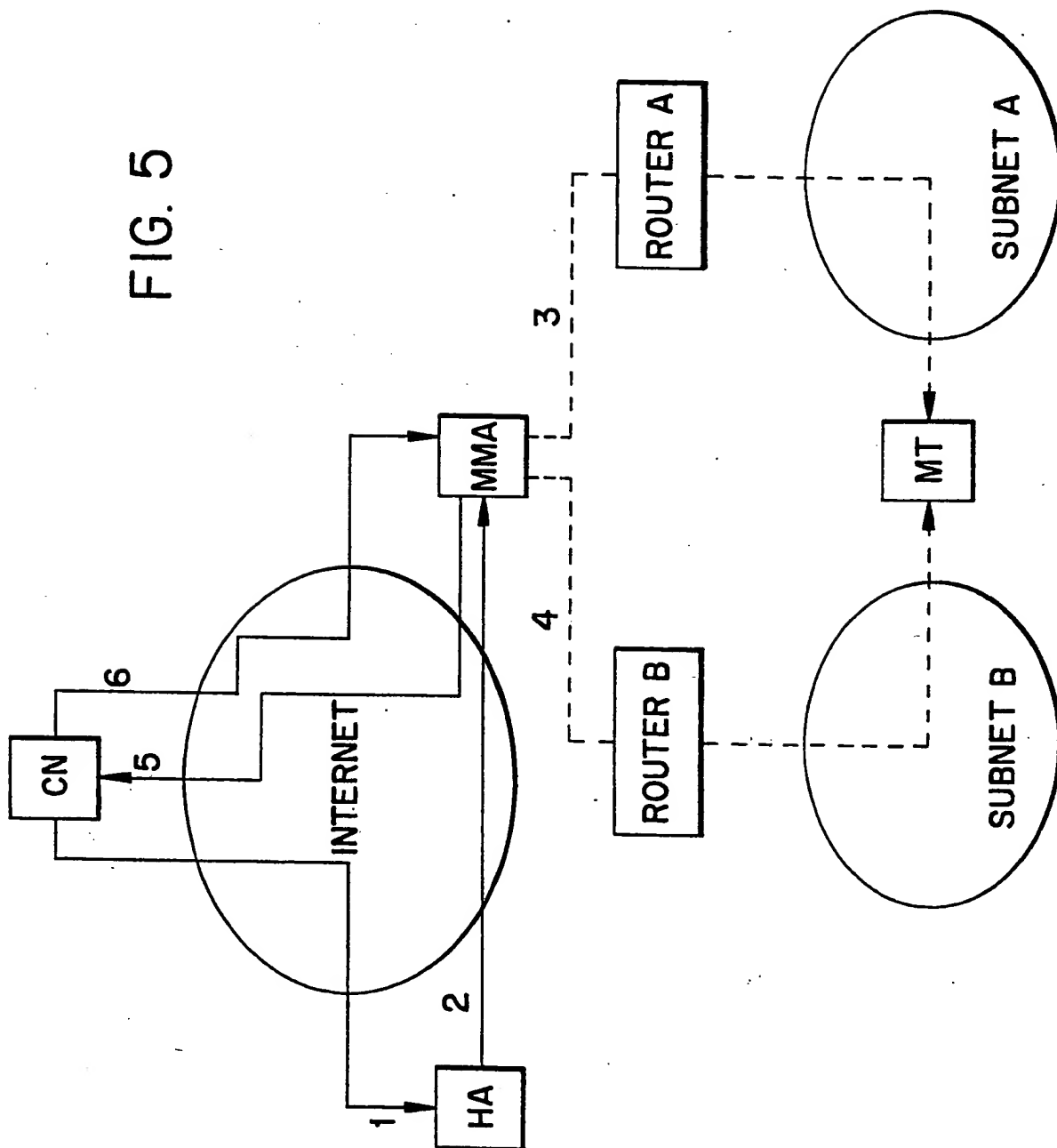
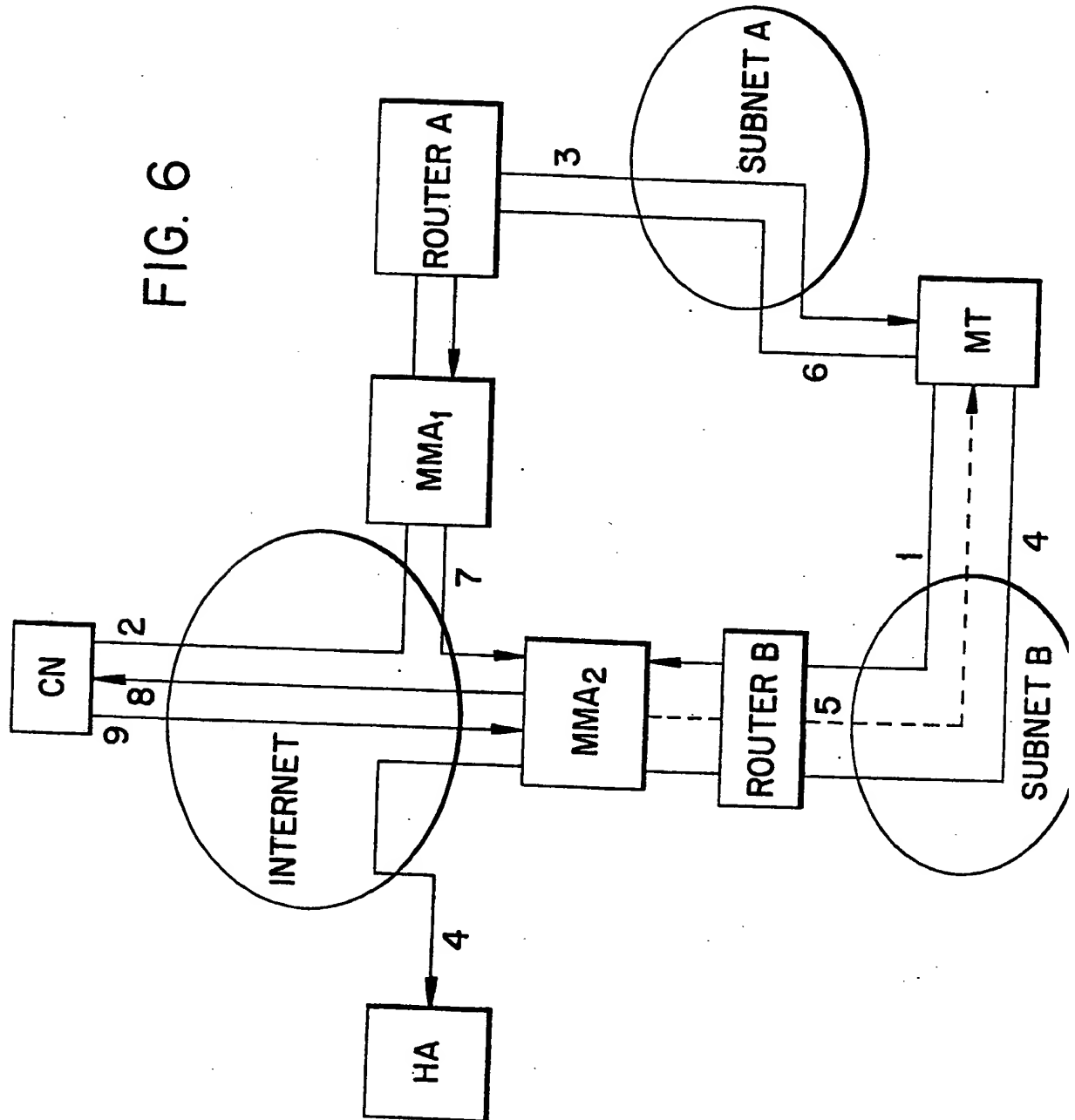


FIG. 6



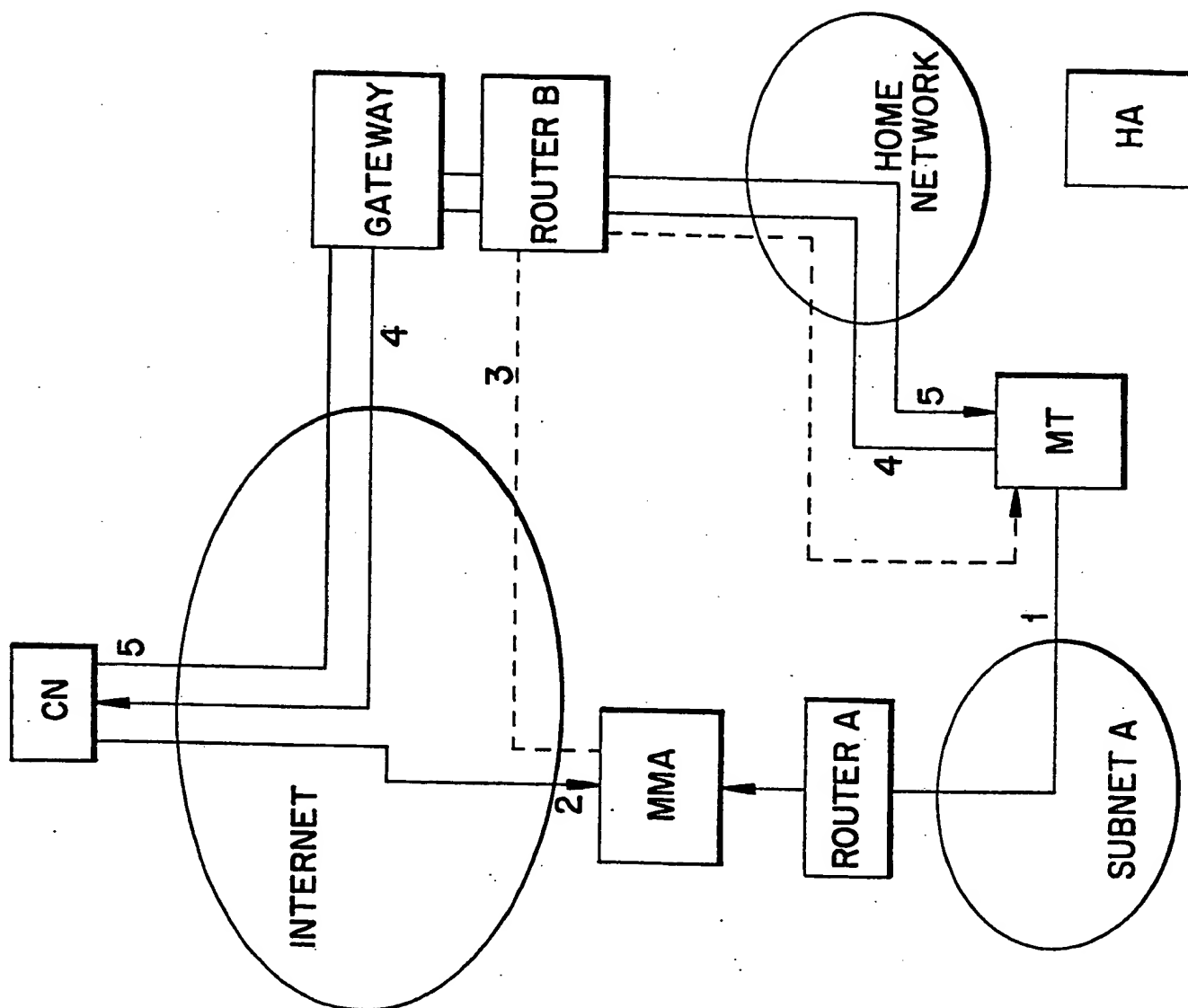


FIG. 7

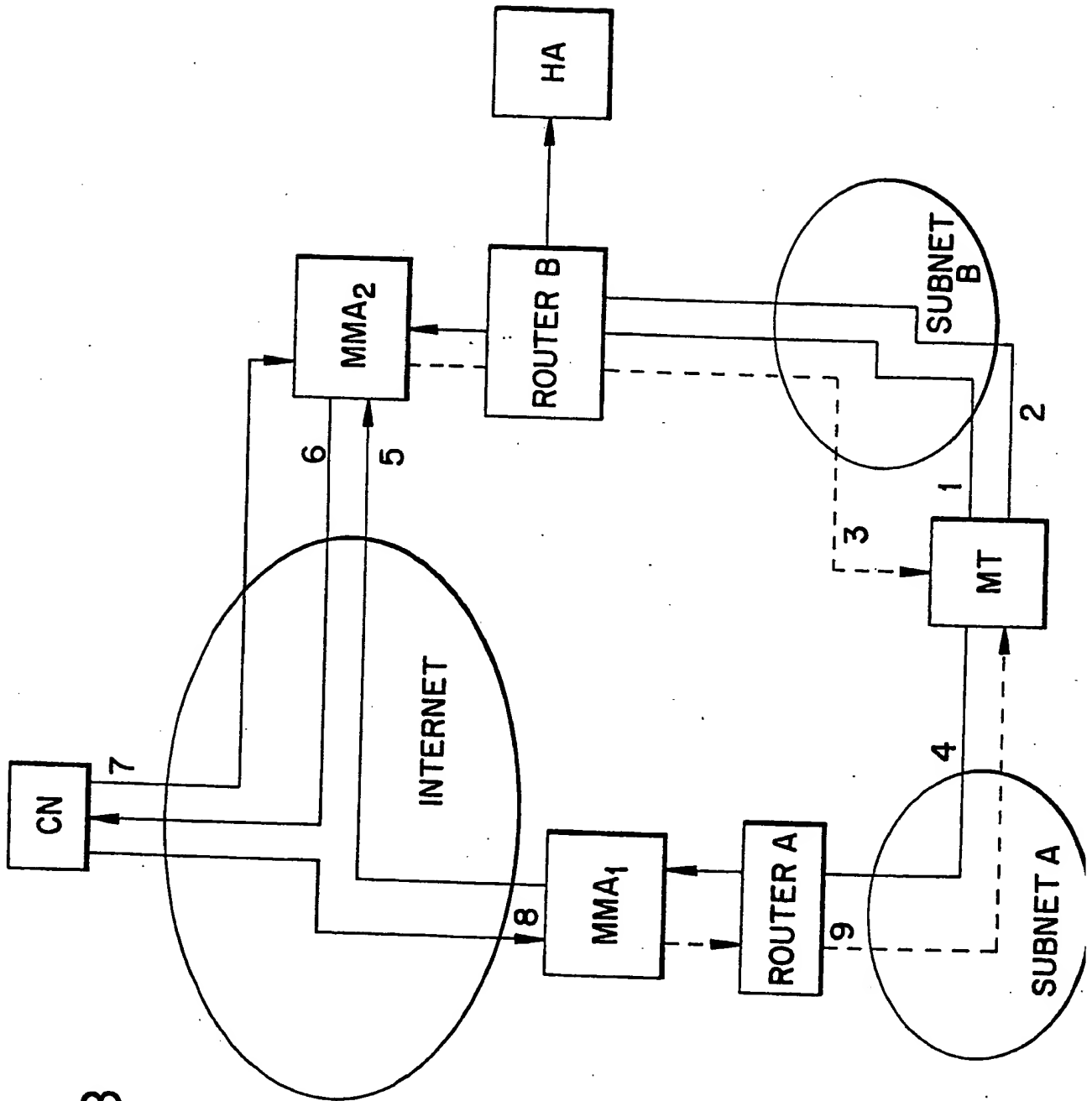


FIG. 8



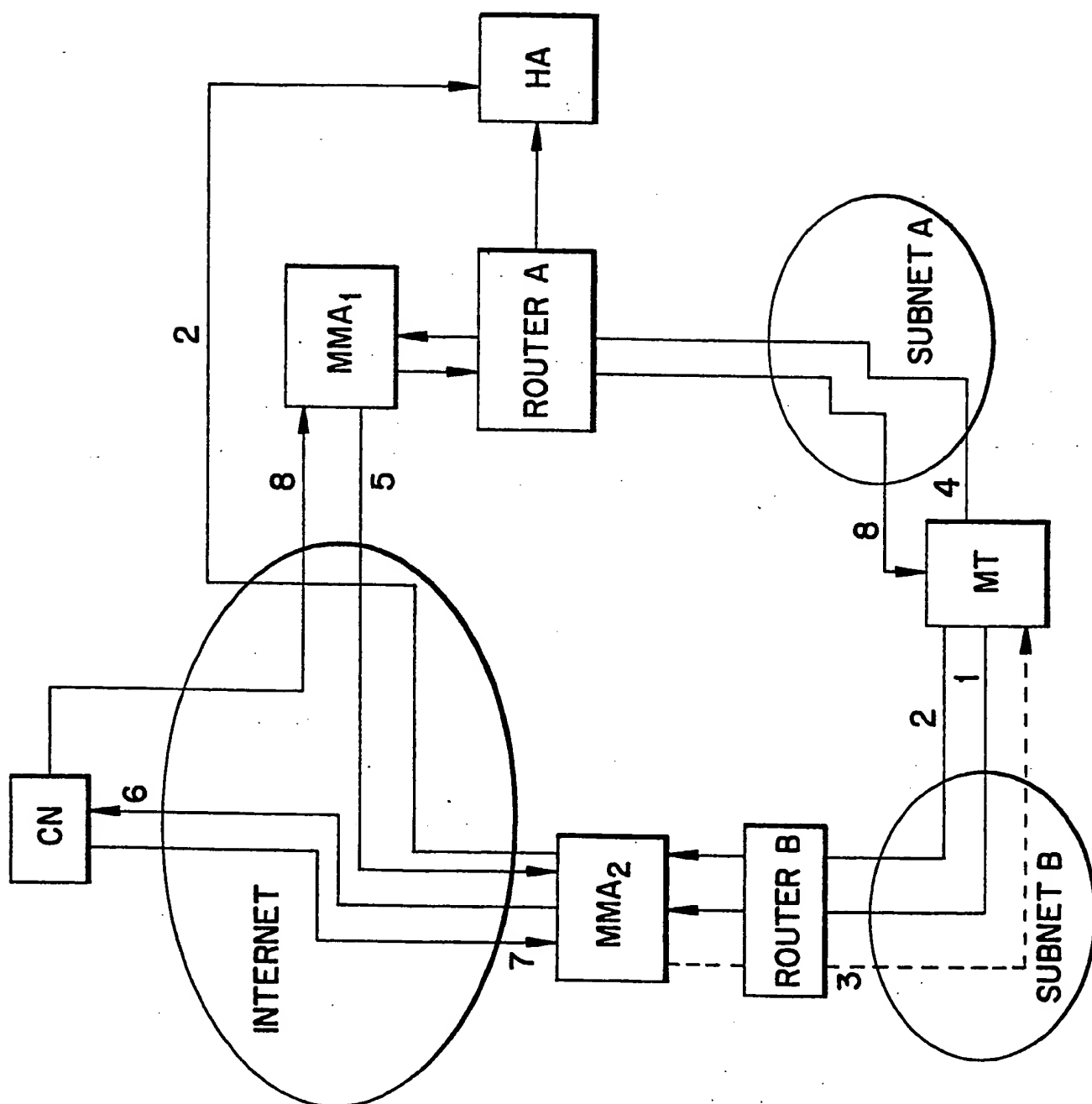
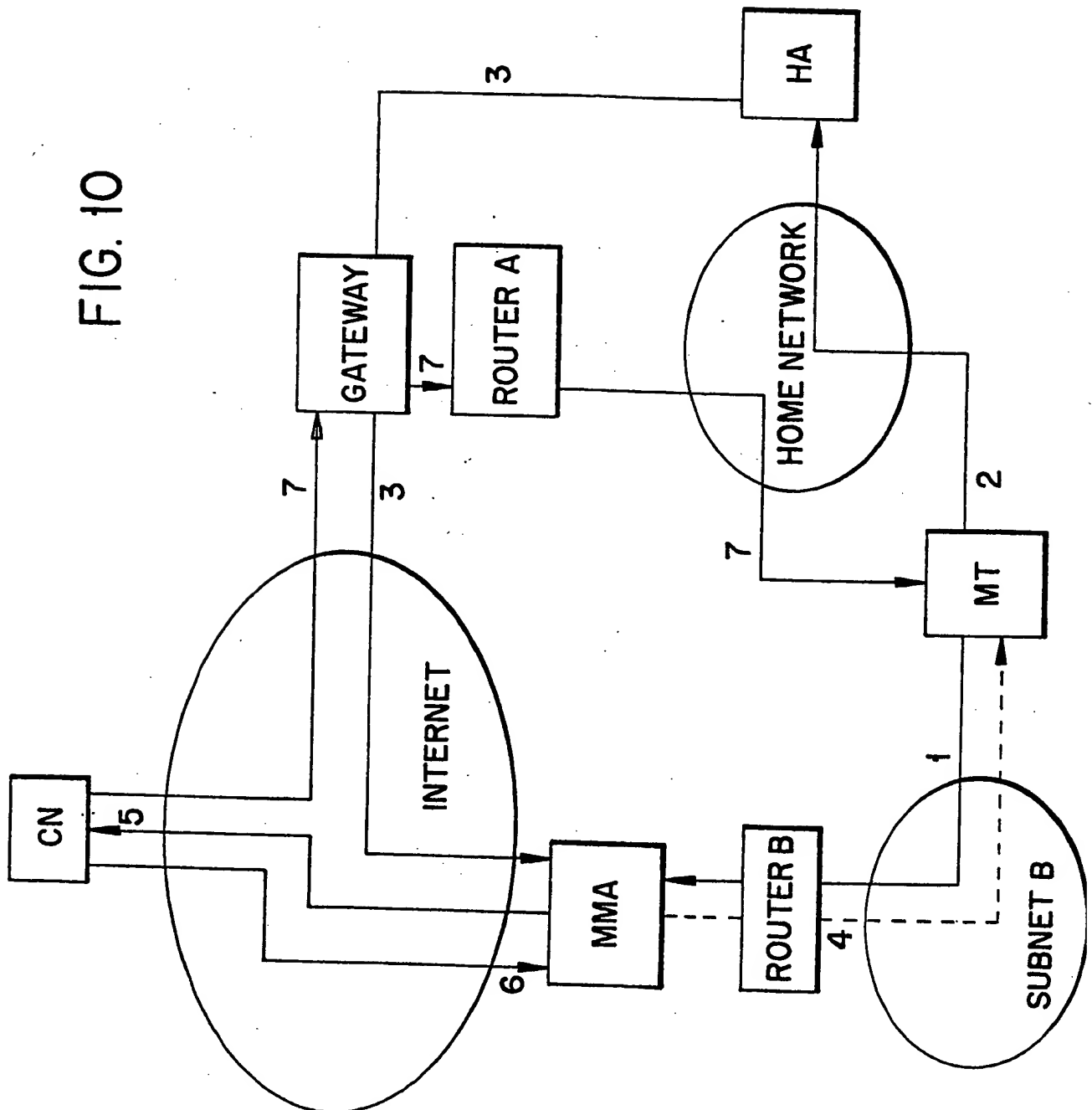


FIG. 9

FIG. 10



# INTERNATIONAL SEARCH REPORT

Inter. Appl. No.

PCT/SE 00/00458

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04L29/06 H04L12/18 H04L12/28 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No.     |
|------------|---|---------------------------|
| X          | MYSORE J.P. ; BHARGHAVAN V.: "Performance of transport protocols over a multicasting-based architecture for Internet host mobility"<br>ICC '98 1998 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS, 7-11 JUNE 1998, ATLANTA - USA,<br>vol. 3, 1998, pages 1817-1823, XP002115329<br>New York - USA<br>the whole document | 1-6,<br>8-15,<br>17-41,43 |
| Y          | ---   | 7,16,42                   |
|            | ---   | 7,16,42                   |

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

26 July 2000

Date of mailing of the international search report

04/08/2000

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**C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category * | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No.                                     |
|------------|---|---|
| X          | <p>SESHAN S ET AL: "HANDOFFS IN CELLULAR WIRELESS NETWORKS: THE DAEDALUS IMPLEMENTATION AND EXPERIENCE" WIRELESS PERSONAL COMMUNICATIONS, vol. 4, no. 2, 1 March 1997 (1997-03-01), pages 141-162, XP000728589<br/>ISSN: 0929-6212<br/>abstract<br/>paragraph '0001! - paragraph '0002!<br/>paragraph '0005!</p>                            | <p>1-6,<br/>8-15,<br/>17-24,<br/>27-31,<br/>35-41, 43</p> |
| A          |   | <p>7, 16, 25,<br/>26,<br/>32-34, 42</p>                   |
| Y          | <p>DEERING S ET AL: "THE PIM ARCHITECTURE FOR WIDE-AREA MULTICAST ROUTING" IEEE / ACM TRANSACTIONS ON NETWORKING, vol. 4, no. 2, 1 April 1996 (1996-04-01), pages 153-162, XP000582667<br/>ISSN: 1063-6692<br/>abstract</p>   | <p>7, 16, 42</p>  |
| A          | <p>EP 0 883 266 A (TOKYO SHIBAURA ELECTRIC CO) 9 December 1998 (1998-12-09)<br/>abstract<br/>page 4, column 5, line 11 - page 5, column 8, line 34<br/>page 11, column 19, line 4 - line 42<br/>page 34, column 65, line 26 - line 38<br/>page 37, column 71, line 30 - line 58<br/>page 38, column 74, line 9 - line 20<br/>figure 26.</p> | <p>1, 10, 19,<br/>28, 36</p>                              |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/SE 00/00458

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
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